3/PRTS

APPARATUS AND METHOD FOR COATING THE EXTERIOR SURFACE OF A PIPE

BACKGROUND OF THE INVENTION

1. Field of the Invention: The present invention relates to the application of a coating material to the outer surface of a pipe wherein neither the pipe nor the entire coating apparatus need be rotated to accomplish a coating around a complete circumferential area of the pipe.

2. Description of Related Art: Pipelines laid overland or under water are assembled from generally cylindrical sections of hollow pipe that are suitably joined together. A typical section that is used to fabricate an oil or gas pipeline has a length of approximately 20 metres and an outside diameter ranging from approximately 1 to 20 metres. A suitable joining process, such as welding, is used to join the pipe sections together. Each section of pipe is manufactured with an exterior coating that typically consists of an inner protective coating layer and an outer insulative layer. The protective layer, with a typical thickness of 1 mm, is formed by rotating the section of pipe whilst the material is applied to the pipe. A suitable composition is a fusion-bonded thermoplastic powder with an epoxy, polypropylene or polyethylene base that is applied to a pre-heated rotating section of pipe. The insulative layer, with a thickness generally on the order of 50 to 60 mm, is typically applied by an extrusion process. In order to join sections together, the insulative and protective coating layers must be cut or stripped back from each end of a section to expose the pipe material for the joining process. After the joining is completed, the exterior coating must be restored in the field to ensure integral coating of the pipeline. When a thermoplastic material is used, the coating material, in powdered form, is applied to the exterior of a pipe that has been preheated to achieve fusion of the material when it comes in contact with the pipe. For ferrous pipes, heating is generally accomplished by magnetic induction. Prior art

processes and apparatus for accomplishing this task are disclosed in U.S. Patent No. 4,595,607. An adhesive material, which can be a polypropylene-based composition, is normally applied over the protective coating by a similar process. Finally, the thicker insulative material is laid over the adhesive by an extrusion process.

Exterior protective coating of an entire pipe may be accomplished by an electrostatic process in which a pipe that has an induced charge on its surface is rotated over a coating material having an opposing charge.

A disadvantage of the prior art is that either the entire coating apparatus or the pipe must be rotated to achieve a full 360-degree coating of an area around the outer perimeter of the pipe.

Therefore, there exists the need for apparatus and method that can apply a 360-degree perimetrical band of coating material to the exterior surface of a pipe without rotating either the pipe or the coating apparatus.

An object of the present invention is to provide apparatus and method for applying a coating material around the complete perimeter of the exterior of a pipe without rotating the pipe or all components of the coating device. An outer stationary or stator element remains static whilst an inner rotor element is used to achieve a 360-degree perimetrical coating.

Another object of the present invention is to provide apparatus and method for applying a coating material around the complete perimeter of the exterior of a pipe without rotating the pipe or the coating device. The entire coating device remains stationary whilst a 360-degree perimetrical coating of the pipe is achieved.

BRIEF SUMMARY OF THE INVENTION

In its broad aspects, the present invention is an apparatus and method for application of coating material to the exterior surface of a pipe. The apparatus surrounds the exterior surface of the pipe and comprises a

stationary component or stator, and a rotating component, or rotor. The rotor is located within the stator and is free to rotate around the pipe relative to the fixed stator. The rotor comprises at least one internal gallery or enclosed passage that extends substantially around the rotor. One or more coating heads are attached to the rotor. Each coating head has an internal passage that is connected to the gallery and an opening for ejecting the coating material onto the exterior surface of the pipe. The coating material is supplied from an external source to the gallery. Positive air pressure is maintained within the gallery to force the coating material out of the opening in the coating head.

In another aspect, the present invention is an apparatus and method wherein the pipe and entire coating apparatus remains stationary whilst a complete circumferential area on the exterior of the pipe is coated. Coating material is supplied at a positive air pressure into a compression chamber within a substantially annular body of the coating apparatus. The compression chamber is substantially continuous around an inner radius of the body. Air pressure forces the coating material through the compression chamber and into one or more diffusing chambers, which are also within the body of the coating apparatus and are substantially continuous around an inner radius of the body. Coating material exits the diffusing chambers into a gallery on the inner side of the annular body. An interchangeable centre section is positioned against the gallery. The centre section has one or more openings in it to eject coating material from the galley and onto the exterior surface of the pipe.

These and other aspects of the invention will be apparent from the following description.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. 1 is a front elevational view of one example of a coating apparatus of the present invention.

FIG. 2 is a cross-sectional view of a coating apparatus with sectioning plane defined by line A—A in **FIG. 1**

FIG. 3 is a cross-sectional view of a coating apparatus with sectioning plane defined by line B—B in **FIG. 1**

FIG. 4 is a side partial cross-sectional detail of one example of a means for driving the rotor of the coating apparatus shown in **FIG. 1**.

FIG. 5 is a cross-sectional view of one example of a coating head used with the coating apparatus shown in **FIG. 1**.

FIG. 6 is a front elevational view of another example of the coating apparatus of the present invention.

FIG. 7 is a cross-sectional view of the coating apparatus with sectioning plane defined by line C—C in **FIG. 6**.

DETAILED DESCRIPTION OF THE INVENTION

There is shown in **FIG. 1** though **FIG. 5** a first example of coating apparatus **10** of the present invention. Substantially annular rotor elements **20** and **22** are suitably joined together to form a rotor. Enclosed within the rotor is a gallery **24** (hidden and shown by dashed lines in **FIG. 1**) that extends substantially around the rotor. The rotor has a central axis that is common with the central axis of pipe **90** (shown in cross-section in **FIG. 1**). Stator elements **26** and **28** are disposed around the rotor and suitably joined together to form a stator. Means for providing free rotation

of the rotor relative to the stator such as the ball bearings **30** shown in **FIG. 2** are provided. Whilst the stator and rotor for the example in **FIG. 1** are formed from two elements, they may be fabricated in different fashion to suit other materials and methods of assembly without deviating from the scope of the invention. Furthermore, whilst the stator in **FIG.1** is shown as a substantially annular structure, in other examples, the stator may be of another shape, such as rectangular. The stator and rotor may be machined from hard anodized aluminum and coated with a friction reducing material such as TEFLON to provide a favorable boundary surface in the internal passages as further described below.

As stated above, a suitable, but not limiting, coating material is a fusion-bonded epoxy in powdered form. The coating material is provided from an external source via a suitable pipe or tubing (not shown in the drawings) that is connected to material port **32** of vacuum displacement pump **34**. Air port **36** on the pump is connected to a regulated compressed air supply (typically from 30 to 30 psi for this example) by suitable pipe or tubing (not shown in the drawings). Regulating the supply of air to a venturi in pump **34** controls the intake draw of coating material into the coating apparatus and provides the means for keeping the coating material within the apparatus under positive air pressure. The term "fluidized" powder can be used to describe the coating material as it mixes with the injected air and reduces in density to a state suitable for passage within the coating apparatus of the present invention. A particular advantage of the present invention is that the non-rotating rotor provides a stationary structure for mounting each vacuum displacement pump. Therefore, the coating material and compressed air connections to each pump are not complicated by connecting to a rotating element.

Whilst the coating apparatus **10** shown in **FIG. 1** uses two vacuum displacement pumps disposed on one of the two stator elements,

other examples of the invention can have a different number of pumps that are attached to one stator face, or distributed between both stator faces.

Pump outlet **38** injects the fluidized powder into gallery **24**. Seals **40** serve as means to keep the powder within the gallery as the rotor rotates relative to the stator and pump outlet **38**. The seals arc designed to withstand the positive air pressure exerted on the powder within the gallery. As shown in **FIG. 3**, pressurized air may optionally be blown into one or more ports **33** on the rotor to assist in maintaining a positive air pressure on the seals **40**.

Coating material is ejected from the gallery **24** through one or more coating heads **42** that are attached to the rotor and have an internal passage connected to the gallery. When the coating material is a thermoplastic material, pipe **90** will be preheated prior to the application of coating material to fuse the material onto the exterior surface of the pipe.

Optionally the exterior surface of pipe **90** can be grit blasted prior to coating by providing a suitable grit from an external source via a suitable pipe or tubing that is connected to material port **32** of one or more of the vacuum pumps **34**. Alternatively one or more dedicated grit vacuum pumps can be provided around one or both of the stator faces.

As shown in **FIG. 5**, a coating head **42** can be provided with one or more interior diffusers **46** in the form of a disc or other shape to control the flow of coating material through the head and onto the exterior surface of the pipe. The coating head, including opening **44**, can be configured as best to suit coating material ejection for a particular application. In the present example, diffuser **46** deflects the fluidized powder to the side wall **45** of the coating head so that the powder exits opening **44** in a generally uniform flow profile across the entire width of the opening. Preferably each coating head is removably attached to the rotor so that it can be removed

and exchanged with a head of differing length, or fitted with a length extension fitting so that differing diameters of pipe can be accommodated.

Suitable drive means are provided to rotate the rotor. One method of driving the rotor is shown in **FIG. 4**. Motor **48** is connected to sprocket **50** via output shaft **52**. A chain (not shown in the drawings) engages sprocket **50** and radially projected teeth (not shown in the drawings) on the circular side surface of the rotor to deliver rotational power from the drive motor to the rotor. Whilst two motors are used in this example, a differing number and configuration may be used to suit a specific application.

In applications where the coating apparatus is slipped onto a section of pipe or slid along pipe sections as a pipeline is assembled, the stator and rotor can be formed as continuous elements around their circumferences. In other examples of the apparatus, the stator and rotor can include means for opening and closing around a section of pipe, such as two split or hinged members with interface boundaries **92** shown in **FIG. 1**.

Either the pipe or the coating device may be moved in its axial direction to effect coating along the length of the pipe. When the coating material is a thermoplastic material, pipe **90** will be preheated prior to the application of coating material to fuse the material onto the exterior surface of the pipe.

Optionally when application of a gas prior and during coating is desirable, the gas may be supplied to one or more of air ports **36** or one or more dedicated gas ports provided around one or both of the stator faces to inject the gas into gallery **24** prior and during coating. This is of particular value when polypropylene is the coating material and the gas is heated air that is applied prior and during coating.

Subsequent to coating, a quench fluid, either in liquid or gaseous form, can be supplied from an external source via a suitable pipe or

tubing that is connected to material port **32** of one or more of the vacuum pumps **34**. Alternatively one or more dedicated quench fluid pumps can be provided around one or both of the stator faces.

In applications where a combination of grit blasting and/or quenching are used, suitable valve arrangements can be provided upstream of the input to material port **32** to facilitate selection of the substance that is fed to the port.

There is shown in **FIG. 6** and **FIG. 7** a second example of the coating apparatus **10** of the present invention. The apparatus comprises a substantially annular body **60**, which has a plurality of entry ports **62** protruding from it. The number of entry ports for a particular application is governed by the diameter of the pipe **90** (shown in cross-section in **FIG. 6** and **FIG. 7**) that is being coated and are, in general, symmetrically arranged around its outer perimeter. The annular body **60** can be formed from two machined halves. Hard anodized aluminum is a suitable material. A coating of a friction reducing material such as TEFLON is preferable to provide a favorable boundary surface in the entry ports and other internal passages as further described below.

A mixing chamber **64** is connected to each of the entry ports. The mixing chamber is used as a means to introduce the coating material into the entry port at a positive air pressure. For this particular example, the coating material is introduced into the mixing chamber from fitting **66**. Fitting **66** is attached to chamber **64** and has a material port **68** for connection to an external source of coating material via suitable pipe or tube (not shown in the drawings). Air port **70** in fitting **66** is connected to a regulated compressed air supply (generally with a range from 30 to 40 psi for the present example) by suitable pipe or tubing (not shown in the drawings). Regulating the supply of air to a venturi in fitting **66** controls the intake draw of coating material into the coating apparatus and provides the

means for keeping the coating material (fluidized powder) within the apparatus under positive air pressure. Mixing chamber **64** has an air port **72** attached to it by which generally low pressure (in the range of 4 to 5 psi) and high volume (in the range of 20 to 25 cfm) air from a suitable source such as a low pressure air compressor (not shown in the figures) is supplied. The low-pressure air serves to force the coating material entering the mixing chamber from fitting **66** into entry port **62** and to further reduce the density of powder if required for a particular application.

Intake chamber **74** (hidden and shown as dashed lines in **FIG. 6**) within body **60** transfers the coating material from an entry port to compression chamber **76** that runs substantially around an inner diameter of body **60** (hidden and shown as dashed lines in **FIG. 6**). In this example, the intake chamber has a generally circular cross-section, and the compression chamber has a combination oval and funnel-shaped cross-section. Other shapes are suitable for the compression chamber as long as the chamber serves to compress the coating material under positive air pressure. The coating material is forced by air pressure down through compression chamber **76** and into diffusing chamber **78**. In this example, the diffusing chamber is a substantially oval passage that opens into the sides of gallery **80**. Interchangeable centre section **82** is a collar that is seated within the inner radial surface of annular body **60** to accommodate the outer diameter of the pipe **90** to be coated. One or more appropriate openings **84** are provided through the thickness of the centre section **82** to permit ejection of coating material onto the outer diameter of pipe **90**. In the present example, opening **84** is a substantially continuous circumferential opening in the centre section to permit ejection of coating material 360 degrees around the perimeter of the pipe **90**. In this manner, neither the pipe **90** nor coating device **10** need to be rotated to achieve a complete coating around the perimeter of the pipe. In alternative examples,

satisfactory rotating means maybe provided with the coating device to rotate it if required for a particular coating process. Either the pipe or coating device may be moved in its axial direction to effect coating along the length of the pipe. When the coating material is a thermoplastic material, pipe **90** will be preheated prior to the application of coating material to fuse the material onto the exterior surface of the pipe.

The configuration of the coating apparatus **10** shown in **FIG. 6** and **FIG. 7**, namely with four entry ports **62** arranged substantially 45 degrees apart from each other, can preferably (but not in limitation) be used to deposit a complete 360-degrees band of coating material around the exterior perimeter of a pipe having an outside diameter ranging from approximately 5 to 13 cm. For pipes of larger diameter, a greater number of entry ports can be used without deviating from the scope of the invention.

In applications where the coating apparatus shown in **FIG. 6** and **FIG. 7** is slipped onto a section of pipe or slid along pipe sections as a pipeline is assembled, body **60** can be formed as a continuous element around their circumferences. In other examples of the apparatus, the body can include means for opening and closing around a section of pipe, such as two split or hinged members with interface boundaries **94** shown in **FIG. 6**.

Options similar to those disclosed for the first example of the invention can be used for the second example of the invention shown in **FIG. 6** and **FIG. 7**. Suitable grit can be provided to material port **68** of one or more of the fittings **66**. Alternatively one or more dedicated grit material and entry ports can be provided around the perimeter of annular body **60** for injecting grit into compression chamber **76**. A gas can be supplied to one or more air ports **70** prior and during coating. Alternatively one or more dedicated gas ports can be provided to inject the gas into the intake and compression chamber. A quench fluid can be provided to material port **68** of one or more of the fittings **66**. Alternatively one or more dedicated

quench fluid fittings can be provided around the perimeter of annular body **60**.

In other examples of the invention, a magnetic induction heating assembly may be combined with the coating apparatus of the present invention to form a single stationary apparatus for preheating and coating around a complete circumferential area of the pipe.